# Frontal Studies in the South China Sea: High-Resolution Hydrographic Surveys at the Shelfbreak (ASIAEX)

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## LONG-TERM GOALS

The long-term goal is to understand thermohaline and velocity structure near a low-latitude shelfbreak, and their effect on sound propagation between the continental shelf and slope.

## OBJECTIVES

The primary objective is to continue analysis of the ASIAEX data sets to establish the dynamics of dominant processes contributing to variability at the shelfbreak in the South China Sea. We are contrasting two years, one in which there was a strong Kuroshio Intrusion and a second in which the Intrusion was absent.

## APPROACH

We have been analyzing the SeaSoar data in the primary ASIAEX study region in the South China Sea. We have computed the geostrophic velocity shears and are comparing them to the shipboard ADCP velocities to establish the relative contributions of the geostrophic flow versus the internal tide

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**The long-term goal is to understand thermohaline and velocity structure near a low-latitude shelfbreak, and their effect on sound propagation between the continental shelf and slope.**

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for the vertical shear of the velocity field. We are also investigating the dynamics of the internal tide field within the region, which contribute substantially to the complex velocity fields which were observed. We are collaborating with R. Preller and D. Ko at NRL-Stennis to diagnose how well a numerical model of the region is generating the Kuroshio Intrusion and the sensitivity of the generation process to model parameters.

**WORK COMPLETED**

We have completed the descriptive analysis of the Pilot Study data set from 2000. This includes filtering of the density and velocity fields, comparison of geostrophic shears to the shipboard ADCP velocities, and transport and relative vorticity fields for the Kuroshio Intrusion. Work on the major field work from 2001 is underway. This data set is substantially larger and contains many interesting processes including a slope current to the southwest at 15 cm/s, internal bores propagating shoreward from the shelfbreak, and passage of large amplitude internal solitary waves across steep topography. A series of numerical model runs have been diagnosed (in collaboration with D. Ko and R. Preller) examining the sensitivity of the model circulation in the South China Sea to wind stress curl, data assimilation of altimeter heights, and boundary inflows.

**RESULTS**

The Kuroshio Intrusion in 2000 contained strong (50-60 cm/s) northward flows across topography. As the Intrusion encountered steep topography, the flow turned eastward and accelerated. The maximum horizontal density gradients were at a depth of 110 m and were substantial; the Kuroshio Intrusion water was 1.0 kg/m^3 less dense than the ambient South China Sea water. The eastward flow along topography had surface velocities as large as 90 cm/s (Figure 1). The relative vorticity within the Intrusion was comparable to the Coriolis parameter, indicating the possibility of significant non-linearity in the dynamics of the Intrusion. The vertical scale of the Intrusion was approximately 200 m, with a nearly linear decrease of the eastward velocity from 20 m down to 200 m. The high degree of baroclinicity is likely responsible for the ease in which the Intrusion crosses deeper isobaths; essentially the current turns when the intrusion encounters topography shallower than the vertical scale of the current.

In 2001, there was no Kuroshio Intrusion present within the study area. Mean flows from the shipboard and moored ADCP's indicate flow to the southwest (the opposite direction to the previous year!) with a magnitude of 15 cm/s. The flow was a maximum at a depth of 100 m. The most dramatic features, however, were associated with both internal bores and internal solitary waves (Figure 2). The bores lead to significant vertical displacements of the fluorescense maximum shoreward of the shelfbreak, although peak values of fluorescense were located near the shelfbreak. Work is presently underway on the analysis of the tides, which are quite complex due to the energetic baroclinic tides in the region. We are also interacting with a number of other ASIAEX investigators on understanding the transformation of the solitons as they pass from deep to shallow water, and the day to day variability in the amplitude of the soliton packets.

We have begun a diagnostic study of the NRL numerical forecasting system for the South China Sea (NSCSNFS) by repeatedly running the model, starting at the same forecast state, but applying forcings individually and then comparing the results. Preliminary examination of the volume-averaged kinetic energy over most of the model domain shows that the wind stress and the inflow through Luzon Strait provide most of the system kinetic energy. Surface heat flux and atmospheric pressure make

negligible contributions. Data assimilation has the dynamical effect of damping or relaxing the system to a much less energetic state. Without any forcing applied, the system produces large gyre-like circulations that form southwest of Taiwan and appear to propagate along the continental slope toward the southwest. These gyres can also be generated by the large wind-stress curl that occurs on the southwest side of Taiwan.

## IMPACT/APPLICATIONS

The ASIAEX data set in the South China Sea is unique because of the concurrent high-quality oceanographic and acoustic observations. We have been collaborating with acousticians J. Lynch and T. Duda of Woods Hole, and C. Chiu of the Naval Postgraduate School on effects of the observed environmental variability on observed acoustic fluctuations. A key part of this interaction is the analysis of the moored data, which is being undertaken by S. Ramp of the Naval Postgraduate School, and D. Tang of National Taiwan University.

Outside of the ASIAEX investigators, we have been collaborating with D. Ko and Ruth Preller of NRL-Stennis. The analysis we have been doing highlights the sensitivity of the model to various parameterizations and boundary conditions, and will ultimately improve the operational forecast model which NRL is presently running.

## TRANSITIONS

We have no direct transitions at the present time. However, we are working on the impact of oceanographic variability on sonar performance as part of the DRI "Capturing Uncertainty in the Tactical Environment", where this data set will be used to compare with statistics generated from numerical models.

## RELATED PROJECTS

Results from this work will be used for the DRI "Capturing Uncertainty in the Tactical Environment" as well as the DRI "Effects of Sound in the Marine Environment". We are also interacting with investigators on many other ASIAEX projects.

## REFERENCES

None.

## PUBLICATIONS

None

## PATENTS

None

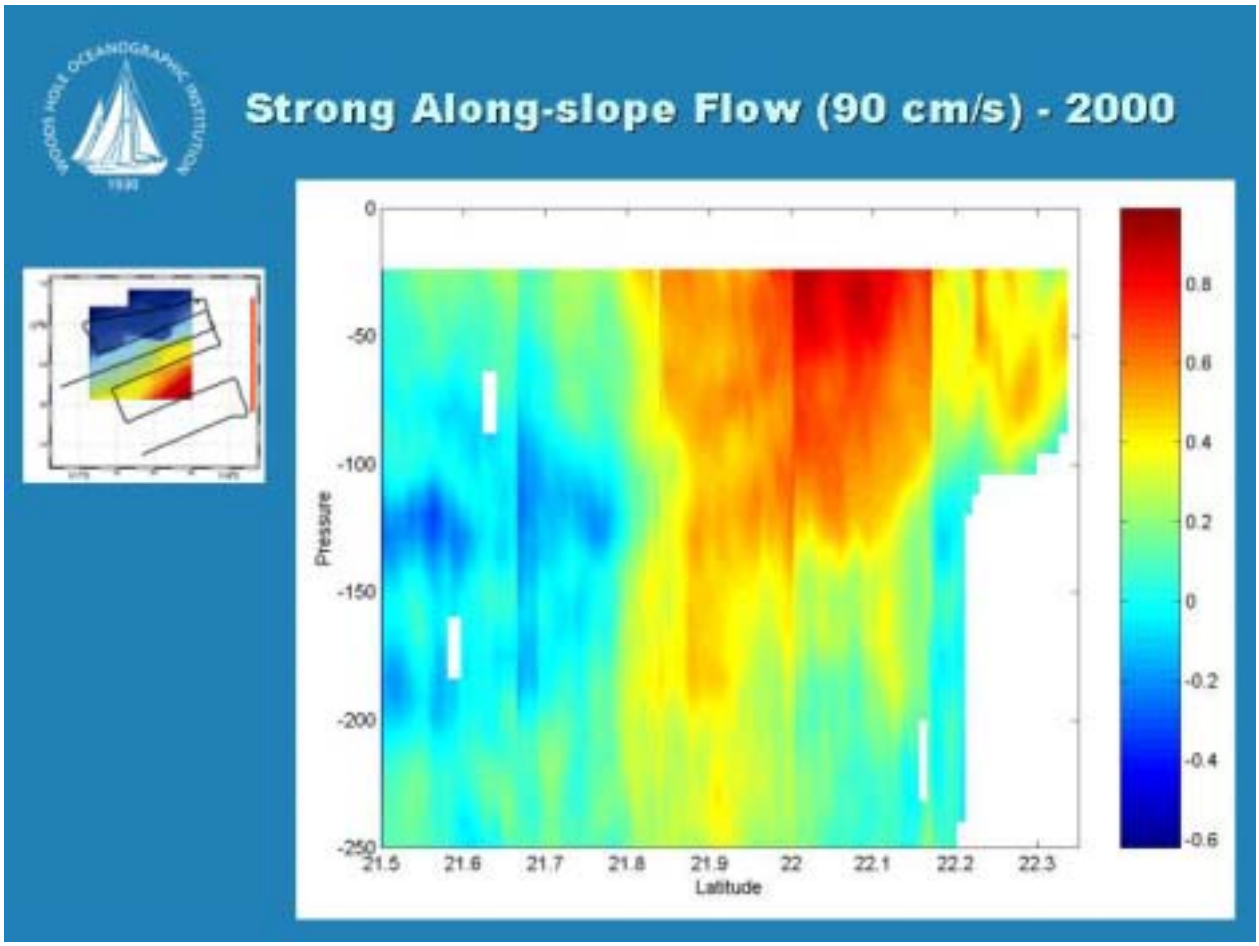


***Figure 1: Alongshelf flow near the shelfbreak from the pilot study in 2000. The maximum flow is 90 cm/s to the east, with a vertical scale of roughly 200 m.***

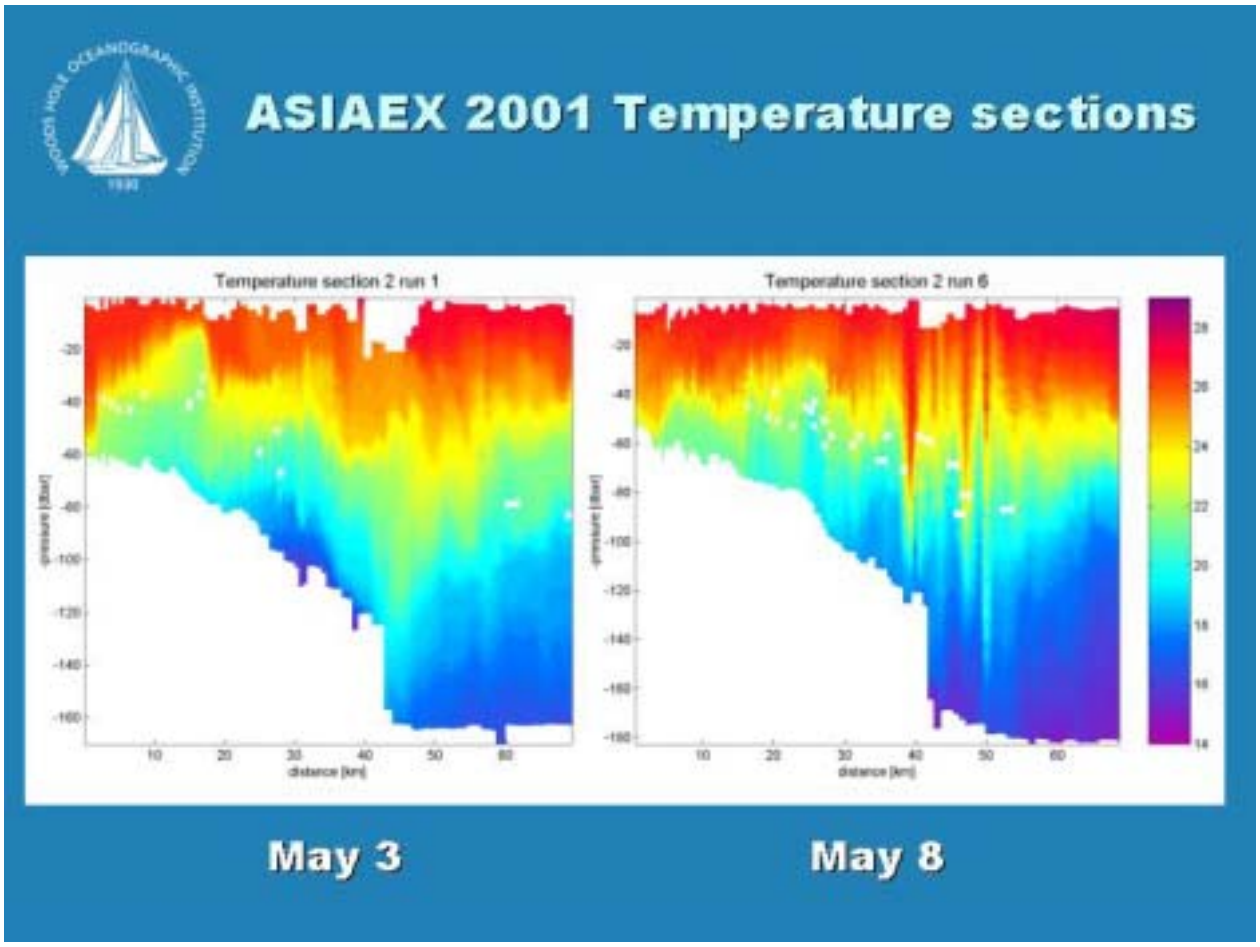


***Figure 2: Temperature fields from two different days from 2001. On May 3, an internal bore was apparent, while on May 8 internal solitary waves propagating from Luzon Strait were present.***